Trace Metal Concentrations in Two Shellfish Species of Commercial Importance

J. B. Palmer and G. M. Rand
Raytheon Company
Oceanographic & Environmental Services
P.O. Box 360
Portsmouth, R.I. 02871

Cadmium is a ubiquitous, non-essential element which possesses high toxicity to both humans (BETON et al., 1966; FRANT and KLEEMAN, 1941; KOBAYASHI, 1970; TOWNSHEND, 1968) and aquatic organisms (BIESINGER and CHRISTENSEN, 1972; EATON, 1974; EISLER, 1971; PICKERING and GAST, 1972). In recent years, cadmium and cadmium compounds have been used extensively by different industries (electroplating plants, mining, pigment works, etc.) producing sharp increases in contamination of air, water and soil (FLEISCHER et al., 1974; FRIBERG et al., 1971). Humans, in turn, may be exposed from a number of different routes, but that through food seems to be the most important. Many studies have investigated the cadmium content of foodstuffs (ISHIZAKI et al., 1970; LENER and BIBR, 1970; SCHROEDER and BALASSA, 1961). These indicate that "normal" levels are below 0.05 ppm, wet weight, with the exception that certain seafoods may contain higher concentrations (ISHIZAKI et al., 1970; SCHROEDER and BALASSA, 1961).

The Public Health Service (Shellfish Sanitation Branch) continually collects and maintains data on metal levels in shellfish from approved shellfish areas. On the East Coast, three species are surveyed: the quahaug, *Mercenaria mercenaria*; the surf clam, *Spisula solidisma*; and the eastern oyster, *Ostrea virginica*. While a standard for cadmium in shellfish does not exist, the highest value for this metal in any of these shellfish from approved areas is 1.9 ppm (wet wt.) (PHS data, April 1976). In the present Public Health Program, neither the sea scallop *Placopecten magellanicus* nor ocean quahaug *Arctica islandica* are regularly surveyed (LAMB, 1976). Both species are found in deeper continental shelf areas and hence presumably farther removed from coastal sources of contamination.

In recent years in the mid-Atlantic, the marketing of the sea scallop has become increasingly important with landings between 1974 and 1975 increasing by 81% (PILEGGI and THOMPSON, 1976). Furthermore, more than 80% of these commercial landings were caught between 12 and 200 miles offshore (a total of 3557 kg, wet weight with shell). There is at present much more limited fishing for the ocean quahaug; however, the potential for commercial exploitation is great (SAILA and PRATT, 1973).

In view of the present importance of the sea scallop and the potential of the quahaug in the shellfish industry, in addition to the lack of published information on cadmium levels in these species, we present here some data on cadmium (and other trace metals) in these organisms. Samples are from a region of the continental shelf (Figure 1) which at present is reportedly fished for scallops (SAILA and PRATT, 1973). This area is removed from any large-scale inputs of trace metals from human activity (e.g. dredge spoils, industrial or municipal sewage sludge disposal).

METHODS AND MATERIALS

Shellfish were collected during three surveys (September-October 1974; April 1975; July-August 1975) with a Crawford rocking chair dredge (effective mouth width 51 cm) and a 9.2 m Wilcox bottom trawl. Animals were removed from the collection gear on deck and placed immediately in Ultrex-grade nitric acid-washed, high-density linear polyethylene plastic bags and frozen.

Shellfish were shucked, thawed, and pooled in the laboratory. All trace metal sample preparation except for mercury involved sulfuric acid - nitric acid ashing followed by atomic absorption or atomic emission spectrophotometry. In the case of mercury, the above two reagents were used, but followed by potassium permanganate digestion with analysis by the cold vapor technique.

RESULTS

Data are summarized in Tables 1 and 2 in ppm, wet weight. Included are data for six other trace metals as well as cadmium. The mean values for cadmium in the sea scallop and ocean quahaug are 3.05 and .40 respectively, or a ratio of 7.63. Similar ratios for the other metals average one or less.

DISCUSSION

All metal ratios except cadmium are what might be expected on an anatomical basis, assuming approximately equivalent ability to concentrate metals in the two species. Since relatively more of the whole scallop is muscle and metals tend to be concentrated more in the visceral mass than muscle, the generally lower values for the sea scallops are reasonable. However, the values for cadmium are high which may indicate a propensity to

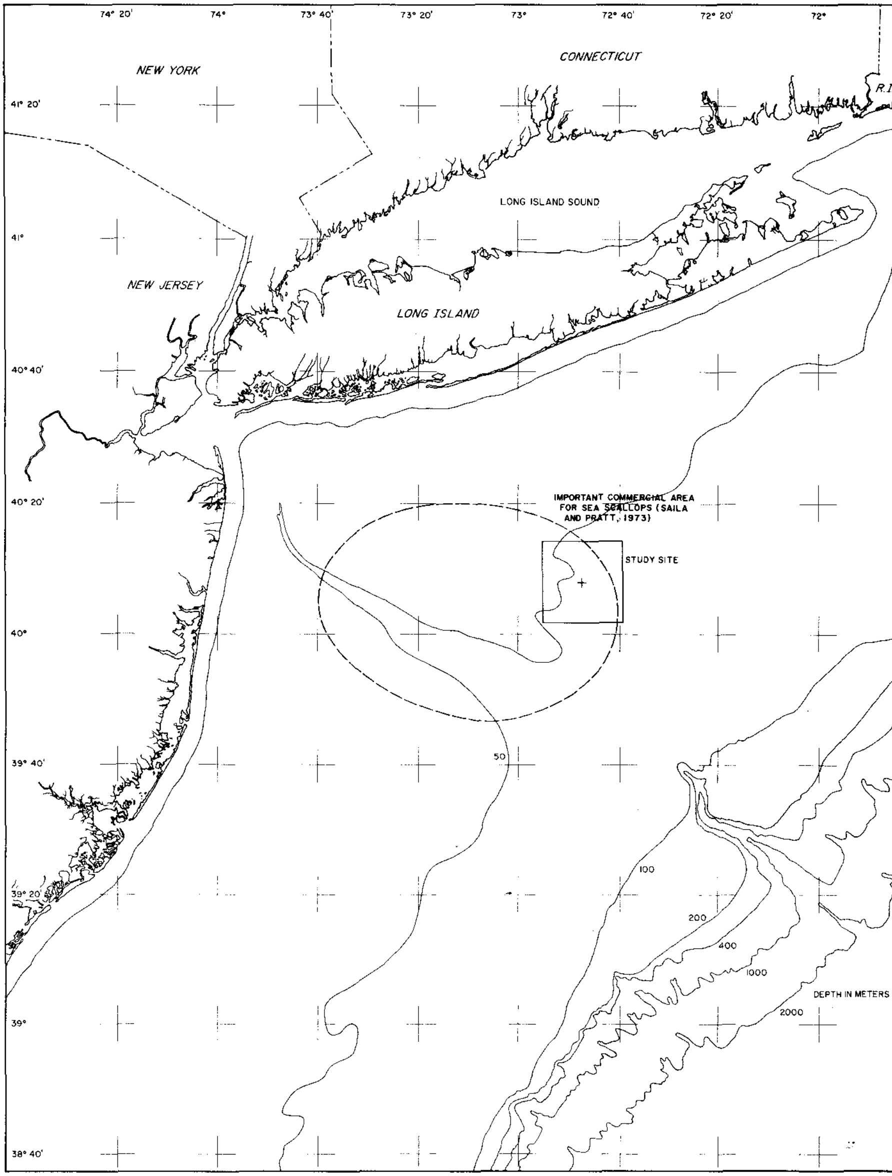

Figure 1. Location of study site and area commercially most important for the sea scallop.

TABLE 1

Mean values and ratios of trace metals in the two shellfish (ppm, wet weight)

Metal	Mean ± Standard Error		Mean Ratios (Placopecten:Arctica)
	Placopecten magellanicus	*Arctica islandica*	
Cadmium	3.05 ± 0.85	.40 ± 0.08	7.63
Chromium	.61 ± 0.17	.71 ± 0.21	.86
Copper	1.45 ± 0.19	2.10 ± 0.34	.69
Lead	1.21 ± 0.17	1.76 ± 0.17	.69
Mercury	.15 ± 0.03	.31 ± 0.11	.48
Nickel	1.71 ± 0.25	3.48 ± 0.49	.49
Zinc	15.89 ± 1.24	14.88 ± 1.92	1.07

TABLE 2

Levels of trace metals in *Placopecten magellanicus* and *Arctica islandica* (ppm, wet weight)

Placopecten magellanicus

Metal	Sept - Oct 1974				April 1975[a]				July - Aug 1975				
Cadmium	8.70	0.80	5.20	8.90	2.30	2.80	<1[b]	0.75	2.02	1.15	1.28	1.58	1.11
Chromium	.84	0.19	0.25	0.40	0.20	2.40	<1[b]	0.26	0.66	0.46	0.69	0.50	0.46
Copper	3.00	1.70	1.10	2.20	0.30	1.00	1.20	1.20	2.00	1.00	1.10	1.50	1.50
Lead	1.80	2.20	1.50	1.50	0.50	0.40	<1[b]	1.30	1.80	0.86	1.20	0.71	0.71
Mercury	.02	0.20	<0.20[b]	<0.20[b]	0.10	0.10	0.10	<0.10[b]	0.18	<0.1[b]	0.19	0.28	<0.10[b]
Nickel	<.5	1.00	0.80	1.10	1.10	3.10	3.30	<1[b]	1.40	2.10	1.40	1.50	2.00
Zinc	109[b]	18.50	9.30	13.80	17.80	18.30	12.30	14.00	24.00	16.00	9.70	17.00	20.00

[a] analyzed by atomic emission

[b] excluded from computations

TABLE 2 (cont)

Arctica islandica

Metal	Survey Date: Sept - Oct 1974			April 1975[a]			July - Aug 1975					
Cadmium	0.90	<0.06	0.20	<1.40[b]	<1.40[b]	<1.40[b]	0.30	0.35	0.25	0.26	0.42	0.49
Chromium	0.87	0.60	0.72	2.50	<0.70[b]	<0.70[b]	0.26	0.62	0.34	0.38	0.46	0.30
Copper	2.00	0.10	2.90	3.80	2.80	0.70	2.40	0.67	3.50	2.30	1.30	2.7
Lead	2.40	1.00	1.30	<1.00[b]	<1.00[b]	1.80	2.40	1.70	1.60	2.60	1.50	1.3
Mercury	<0.20[b]	<0.20[b]	<0.20[b]	0.17	0.32	0.21	1.17	0.25	0.10	0.40	0.10	0.09
Nickel	1.10	7.00	1.3	3.90	4.50	4.10	3.90	4.30	4.5	3.50	2.30	1.40
Zinc	11.5	2.4	13.0	11.60	19.60	25.80	18.00	21.0	19.00	19.00	6.7	11.0

[a]analyzed by atomic emission

[b]excluded from computation

concentrate this metal. This is consistent with other scallop species (BROOKS and RUMSBY, 1965; EISLER, 1971; MULLIN and RILEY, 1956).

High values for cadmium were also noted in the livers of other marine molluscs, for example, some cuttlefish contained 10 to 110 ppm (wet wt.) while *Babylonia japonica*, a roll shell, contained 92 to 420 ppm (ISHIZAKI et al., 1970). Similarly, PRINGLE et al. (1968) reported cadmium concentrations from 0.1 to 7.8 ppm (dry wt.) in oysters from the east coast of the US and from 0.2 to 2.1 ppm in those from the west coast. These findings are in agreement with the known accumulation of many elements, including cadmium, in the molluscs; a fact which may also explain the relatively high values of cadmium in unpolluted areas.

The data also indicate that zinc concentration are high in both organisms. This is not unusual in view of the essential role of zinc in many enzymatic reactions.

The higher levels of cadmium in marine organisms are usually associated with levels in the ambient water usually the result of pollution. However, we have presented data on organisms from an area considered relatively unpolluted and distant from any major sources of inputs. This study has accentuated the need for a systematic, planned survey of the distribution of cadmium in the shellfish along the continental shelf. This should include simultaneous collections of water and sediment. In addition, laboratory investigations of uptake in these species from water and food would be desirable.

It is necessary to determine the relationship, if any, between variation in cadmium values in shellfish, water, and sediment. If this information were available for a large enough synoptic sampling of continental shelf conditions, it would be possible to determine if a case could be made for a direct relation between areas of high metal input and high burdens in shellfish. Existing data are too scattered and lacking in systematic form to allow such an elementary inference.

ACKNOWLEDGEMENTS

Data were gathered as part of a marine baseline survey performed by the Oceanographic & Environmental Services division of Raytheon Company for the United States Environmental Protection Agency (Contract No. 68-01-2770).

REFERENCES

BETON, D.C., G.S. ANDREWS, H.J. DAVIES, L. HOWELLS, and G.F. SMITH: Brit. J. Indust. Med. 23, 292 (1966).

BIESINGER, K.E. and G.M. CHRISTENSEN: J. Fish. Res. Bd. Can. 29, 1691 (1972).

BROOKS, R.R. and M.G. RUMSBY: Limnol. Oceanog. 10, 521 (1965).

EATON, J.D.: Trans. Amer. Fish. Soc. 103, 729 (1974).

EISLER, R.: J. Fish. Res. Bd. Can. 28, 1225 (1971).

FLEISCHER, M., A.F. SAROFIM, D.W. FASSETT, P. HAMMOND, H.T. SWACKIETTE, I.C.T. NISBET, and S. EPSTEIN: Environ. Health Perspectives, U.S. Govt. Printing Office, Washington, DC 7,253 (1974).

FRANT, S. and I. KLEEMAN: J. Amer. Med. Assoc. 17, 86 (1941).

FRIBERG, L., M. PISCATOR, and G. NORDBERG: Cadmium in the environment, p. 166. Ohio: Chemical Rubber Co. 1971.

ISHIZAKI, A., M. FUKUSHIMA, and M. SAKAMOTO: Jap. J. Hyg. 25, 207 (1970).

KOBAYASHI, J.: Proc. Int. Water Pollution Res. Conf., 5th, July-August 1970.

LAMB, J.: Personal communication. Shellfish Sanitation Branch. US Dept. Health Ed. & Welfare, Public Health Service, Washington, DC. 1976.

LENER, J. and B. BIBR: Vitalstoffe Zivilisation - skrankheiten 15, 139 (1970).

MULLIN, J.B. and J.P. RILEY: J. Mar. Research 15, 103 (1956).

PICKERING, Q.H. and M.H. GAST: J. Fish. Res. Bd. Can. 29, 1099 (1972).

PILEGGI, J. and THOMPSON. Fisheries of the U.S. NMFS Current Fisheries Statistics No. 6900. 1975.

PRINGLE, B.H., D.E. HISSONG, E.L. KATE, and S.T. MULAWKA: J. Sanitary Eng. Div. 94, 555 (1968).

SAILA, S.B. and S.D. PRATT: In Coastal & Offshore Environmental Inventory. Marine Experimental Station; Graduate School of Oceanography, Univ. of Rhode Island, Kingston, RI. 1973.

SCHROEDER, H.A. and J.J. BALASSA: J. Chronic Dis. 14, 236 (1961).

TOWNSHEND, R.H.: Brit. J. Indust. Med. 25, 68 (1968).